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Agency

Office of Ground Water and
Drinking Water

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EPA

Analysis of the Effects of EPA Restrictions on the Deep Injection of Hazardous Waste

CONTENTS

LIST OF EXHIBITS

EXECUTIVE SUMMARY

Hazardous waste injection began in the 1950s. Class I hazardous waste (IH) wells inject hazardous waste beneath the lowest underground source of drinking water (USDW). By the early 1980s, approximately half of the liquid hazardous waste disposed of in the United States (approximately 11.5 billion gallons) was injected into these wells.

This report describes how EPA regulations prevent Class IH wells from endangering USDWs. It also documents changes in the Class IH well population and Class IH hazardous waste management practices that have occurred since the regulations were promulgated. The findings of this report are summarized below.

1. **EPA has strengthened operating regulations and has required operators to submit "no-migration" petitions in order to continue operating. This has made underground injection an even safer, more effective waste disposal practice.**

In response to the Safe Drinking Water Act, EPA promulgated regulations in 1980 governing all injection wells including those injecting hazardous waste. In 1984, Congress banned most forms of land disposal of untreated waste, including injection wells, unless EPA determined that the prohibition was not required to protect human health and the environment. In 1988, EPA passed additional regulations requiring Class IH operators to prove protectiveness by submitting a "no-migration" petition demonstrating that waste would not migrate from the injection zone for as long as it remained hazardous. Well operators who do not submit petitions must either treat to remove the banned substances or cease injection of the waste.

2. **EPA established a rigorous Class IH petition review process.**

EPA Headquarters, Regional offices, and State agencies devoted substantial resources to the petition review process: approximately one person-year (over 2000 hours) was spent on each petition. In most cases, Regions needed to commit several professionals full-time to accomplish a detailed petition review. For example, Region VI had sixteen full-time staff members reviewing the petitions for almost a full year.

3. **Petitions provide detailed analysis of migration potential.**

Class IH petitions submitted by well operators were typically several volumes long, contained thousands of pages of technical data, and occupied up to two to three feet of shelf space. The petitions reflected detailed, rigorous analysis of every technical aspect of well siting, construction, operation, and detailed analysis of the injected waste streams.

A team of professionals are assigned to review each petition. Engineers and geologists review information about the construction, operation, compliance history, and closure plans for the well. They evaluate the chemical compatibility of the waste with the materials of well construction, and the injection and confining zone rocks and fluids. Information for the Area of Review is studied to ensure that no migration could occur through unplugged or improperly completed wells which penetrate the confining zone. Geologists evaluate both local and

regional geology by analyzing the scientific literature, core data, cross-sections, and seismic profiles submitted by the petitioner.

For purposes of this study, operators were contacted to determine the cost of preparing complete petitions. The average amount spent to prepare each petition was $343,000. Costs ranged from $50,000 to $1,200,000 with a mode of $290,000. These costs exceeded EPA's earlier estimates.

4. **The Class I hazardous waste restrictions resulted in a significant reduction of the volume of waste injected and in the number of Class IH facilities.**

In 1985 EPA estimated that 11.5 billion gallons of hazardous waste was being injected. By 1990 EPA estimated that this volume had been reduced to 9 billion gallons of hazardous waste. In addition, the number of Class IH facilities has decreased from 95 to 51 between the time Class IH regulations were promulgated and now. Although these reductions are not due solely to the Class I hazardous waste restrictions and may in fact be due to waste reduction efforts by the industries concerned, it is reasonable to conclude that the restrictions influenced the reductions.

Facilities which do not have approved petitions are prohibited from injecting banned waste into their wells. Of the 36 former Class IH facility operators who either withdrew or did not submit their petitions:

- 20 now inject only non-hazardous waste;
- 11 have plugged and abandoned their wells; and
- 5 have temporarily abandoned their wells.

5. **The Class I Hazardous Waste Restrictions program has encouraged pollution prevention.**

Facilities no longer allowed to inject hazardous waste are doing the following with their waste:

- 13 are no longer generating hazardous waste;
- 14 treat their wastes on-site so that it is no longer hazardous; and
- 2 ship the waste off-site.

Seven of the former Class IH injectors have closed their Class I facilities entirely.

1.0 CLASS I HAZARDOUS (IH) INJECTION WELLS ARE USED TO DISPOSE OF HAZARDOUS WASTE

Class I wells used to inject hazardous waste are classified by EPA's Underground Injection Control (UIC) program as Class IH wells.[1] About 50 percent of the liquid hazardous waste generated each year in the U.S. is safely disposed of in secure subsurface geologic formations using Class IH injection wells. The purpose of this report is to assess the effect of Class I regulations on hazardous waste disposal practices and to evaluate the changes in the Class IH well population since the regulations were promulgated. In gathering data for this report, the four Regions in which Class I wells are located were contacted, and Regions V and VI were visited to interview Class I petition staff and to review their files. In addition, Class IH operators were directly contacted by an EPA contractor for information on petition costs and waste disposal practices.

1.1 What Are Class IH Injection Wells?

Although injection wells have been successfully used in the oilfield since 1910, subsurface injection of hazardous waste commenced about 1938 when a well was utilized to dispose of waste brine from a chemical manufacturing process. Class I wells, by definition, inject municipal or industrial waste beneath the lowermost underground source of drinking water (USDW). A USDW is an aquifer or portion of an aquifer that supplies a public water system (PWS), contains enough water to supply a PWS, or which contains less than 10,000 milligrams/liter of total dissolved solids (TDS).[2]

A Class IH injection well consists of several components which serve to isolate injected waste from USDWs. Concentric pipes, known as casing or tubing, extend down a drilled hole known as the well bore. The outermost casing of a Class IH well, called the surface casing, usually extends below the base of the lowermost USDW. A second casing inside the surface casing is called the long-string casing, and consists of one or more pipes extending into the formation where the waste is placed, called the injection zone. The casings are cemented into the hole and to each other to seal the well bore. Inside the long-string casing is the injection tubing, through which waste is injected. The space between the long-string casing and the injection tubing, called the annulus, is filled with a non-corrosive fluid. The annulus is sealed at the bottom by a packer or equivalent, and at the top by the well head seal. A Class I injection well is depicted in Exhibit I.

Casing and tubing material are generally alloy steel or fiberglass, depending on the corrosion characteristics of the injected fluid. Packers are usually machined from corrosion-resistant alloys (e.g., Hastelloy C), but some high-elastomer inflatable packers are in service in some wells. Cement is usually a chemically-resistant latex blend, although many wells use an epoxy resin (e.g., EPSEAL) instead of cement. The mechanical integrity of the tubular

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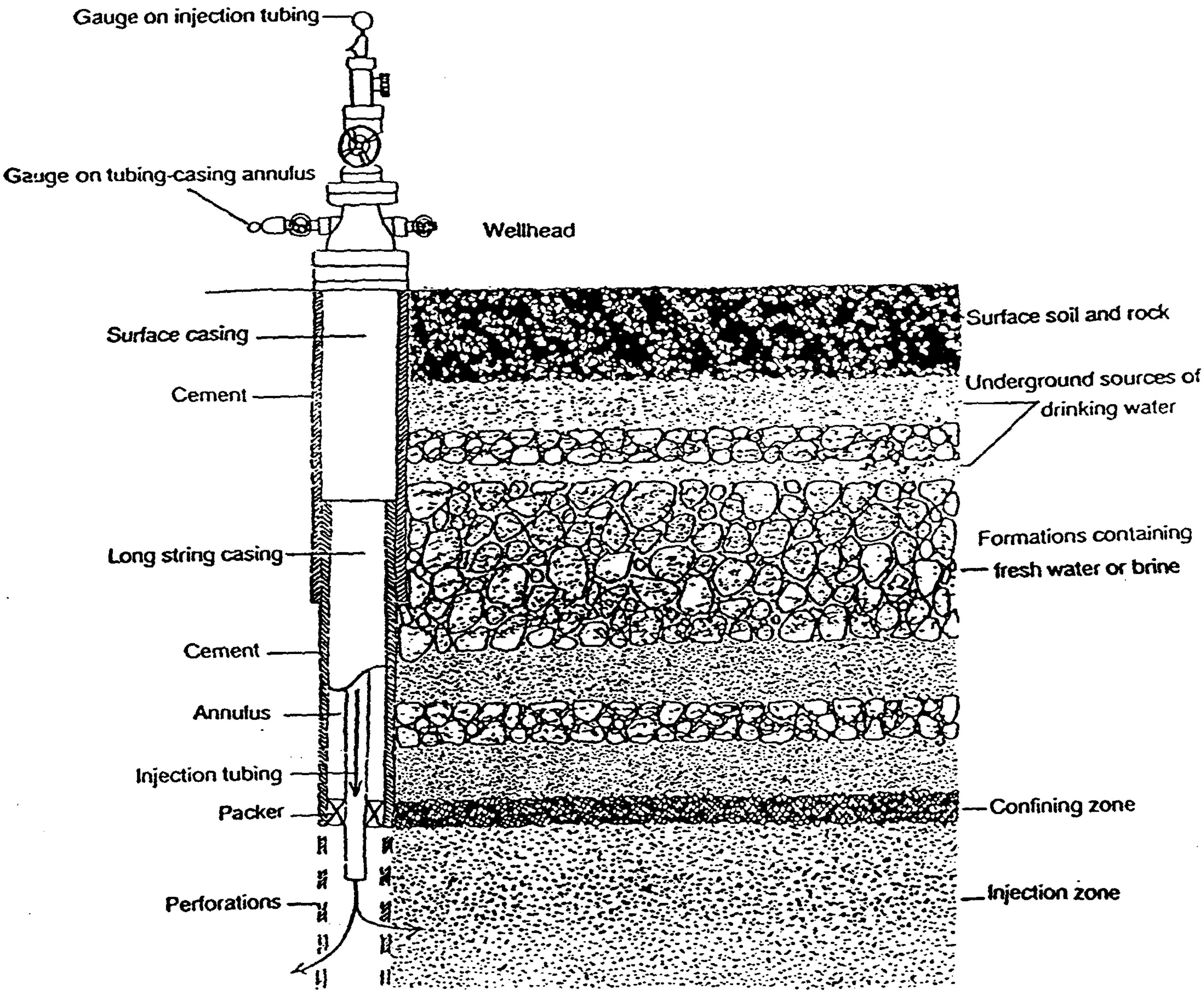
[1] For the purposes of this report, a Class IH facility is defined as one which injects currently banned waste (or would if its petition were approved).

[2] 40 Code of Federal Regulations (CFR) 144.3.

Exhibit I
Class I Hazardous Waste Injection Well



goods (i.e., casing, tubing, packer, or well-head seal) of the well can be directly verified by a pressure test or continuous monitoring of the tubing/casing annulus. The integrity of the cement used to seal the casing at the injection zone is tested using wireline logs (e.g., radioactive tracer tests).

Class IH wells typically inject wastes into zones several thousands of feet below the land surface. In the Great Lakes Region, well depths range from 1700 to 6000 feet. In the Gulf Coast, depths range from 2200 to 9500 feet.

Waste injected into the injection interval disperses through the injection zone. The injection zone is the subsurface geologic layer (usually sandstone or limestone) into which the waste is injected. Above the injection zone is the confining zone, which consists of impermeable rock such as shale or dense limestone that prevents fluids from migrating upward.

1.2 Where Are Class IH Wells Located?

Currently, there are fifty-one Class IH facilities in the U.S. Most are found in EPA Regions VI (38) and V (9). (See Exhibit II.) Texas has the greatest number of Class IH facilities of any State (28), followed by Louisiana (9). (See Exhibit III.)

1.3 Who Uses Class IH Wells?

The industries having the greatest number of Class IH well sites are the chemical products, petroleum refining, and metal products industries. Eleven facilities are "commercial disposal" facilities (i.e., waste management/treatment). (See Exhibit IV.)

1.4 What Are the Risks from Class IH Wells?

EPA originally identified four potential Class IH contamination pathways.[3] These pathways of concern are:

- **Well Failure.** Injection wells can fail internal or external mechanical integrity. Internal failure results from corrosive or mechanical failure of the tubular goods. External failure occurs when fluid moves up the outside of the well due to failures in the cement.

- **Improperly Plugged or Completed Wells in the Area of Review.** Improperly plugged or completed wells which penetrate the confining zone in the vicinity of the injection well can form a conduit for fluids to travel from the injection zone to USDWs. These potential conduits are most common in areas of oil and gas exploration. Because the geologic requirements for Class IH injection activities are similar to those for oil and gas exploration, these activities take place in the same areas. EPA estimates that there may be as many as 300,000 abandoned wells

[3]U.S. EPA, *Report to Congress on the Injection of Hazardous Waste*, EPA 570/9-85-003, May 1985, p. 1-2.

Exhibit II
Class IH Facilities by Region

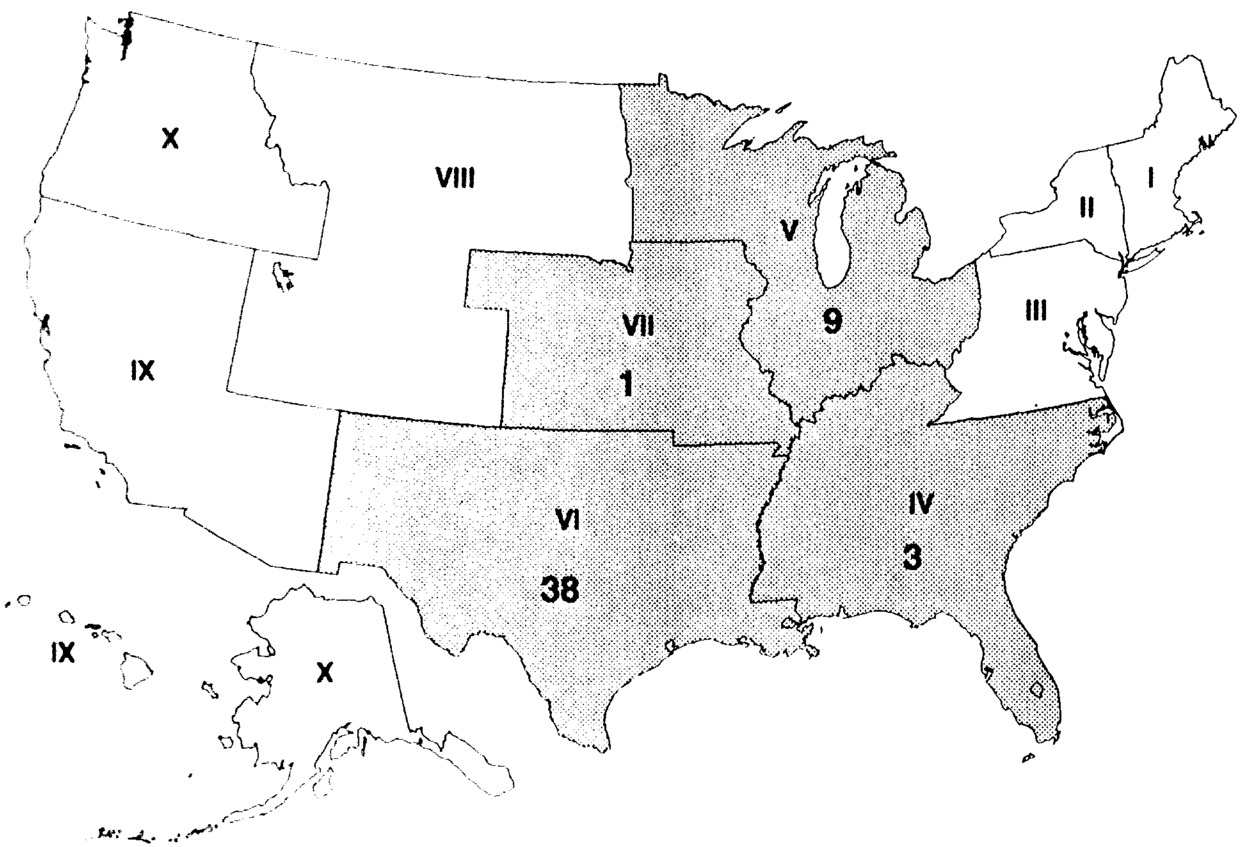


Exhibit III

Class IH Facilities by State

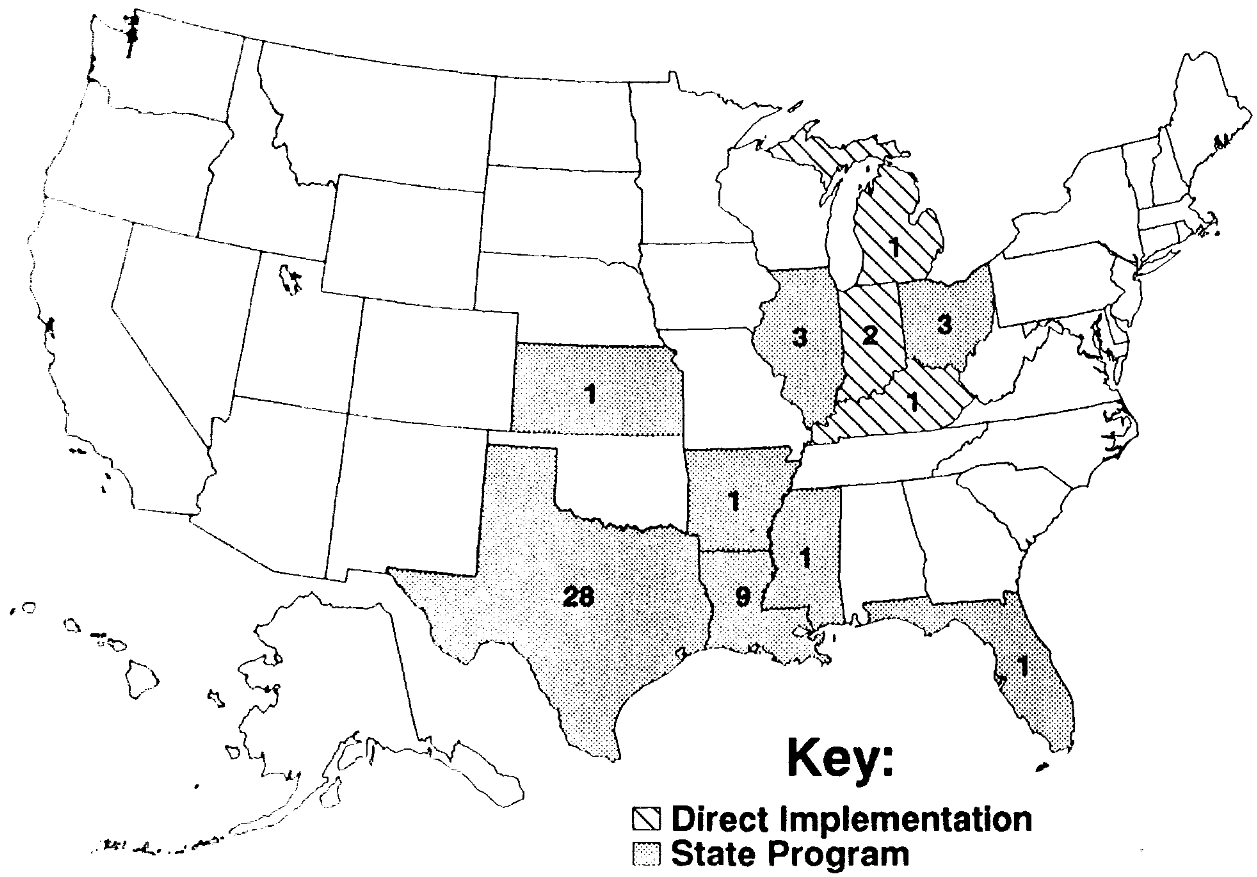
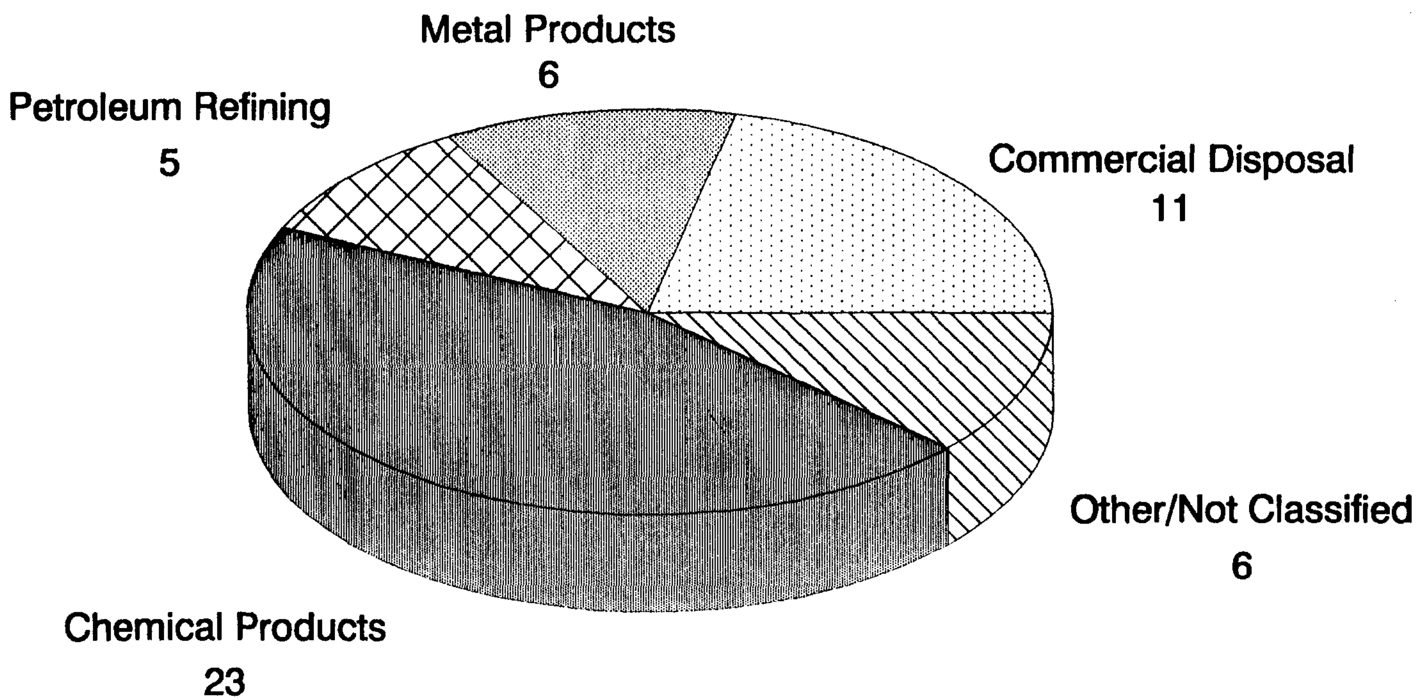


Exhibit IV
Class IH Facilities by Industry



and 100,000 producing wells outside of active oil and gas production fields and potentially in the Areas of Review of Class I injection wells.

- **Faults or Fractures in the Confining Zone.** Transmissive faults can allow wastes to migrate out of the injection zone. Faults or fractures may have existed naturally prior to injection, or pathways may be created by the waste dissolving the rocks in the confining zone. Artificial fractures may also be created by injecting waste at excessive pressures, although this is not perceived to be a usual or probable occurrence.

- **Lateral Fluid Displacement Out of the Injection Zone.** Lateral fluid displacement can contaminate USDWs if the injection interval is hydraulically connected to the USDW. The effects of injection might cause poorer-quality water such as brines or highly saline groundwater to move up-gradient into USDWs.

EPA has promulgated extensive technical regulations to ensure that fluids do not migrate from the injection zone into USDWs. The regulations are listed in 40 CFR 146 and 148 and are described in section 2.1 of this report.

1.5 UIC Regulations Prevent Contamination of USDWs by Class IH Wells

Several studies, some by EPA contractors[4] and some by independent environmental groups,[5] have evaluated the protectiveness of the Class I technical regulations. EPA has reviewed these studies and, in addition, to the Agency's and State's review of the UIC program, has concluded that current regulations are sufficiently stringent to protect USDWs.[6]

Contamination of USDWs by Class IH wells has been rare. EPA and the States have identified two cases where injected wastes contaminated USDWs, and one case where an injection well was suspected of causing the contamination of a USDW. All three cases occurred prior to the implementation of a State or Federal UIC program. EPA has also identified eight cases where leakage from Class IH wells entered non-USDW formations and two cases of surface contamination due to blowouts.[7]

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[4]CH2MHill, *Class I Injection Well Survey-Phase I Report: Survey of Selected Sites*, prepared for the Underground Injection Practices Council, Oklahoma City, Oklahoma, 1986, and Engineering Enterprises, Inc., *Class I Hazardous Waste Injection Wells Evaluation of Non-Compliance Incidents*, prepared for the U.S. EPA, Office of Drinking Water, UIC Contract No. 68-01-7011, 1986.

[5]W. Gordon and J. Bloom, *Deeper Problems: Limits to Underground Injection as a Hazardous Waste Disposal Method*, Natural Resources Defense Council, Inc., New York, N.Y.

[6]53 FR 28131.

[7]*Hazardous Waste: Controls Over Injection Well Disposal Operations*, U.S. General Accounting Office, August 1987.

Both cases of known USDW contamination from Class IH injection wells (Tenneco Refinery #1, Chalmette, LA, 1980 and Velsicol Chemical #1, near Beaumont, TX, 1975) occurred prior to the existence of the UIC program and had the same cause. Both wells were constructed without tubing and packer and without surface casing set to protect all USDWs. Corrosion of the long-string casing (the only layer of protection) allowed the unobserved leakage of wastes to USDWs. The contamination was limited to within 100 feet of the wellbore, and both aquifers were cleaned up using pump-and-treat methods. Later, both injection wells were plugged. UIC regulations would have never allowed this method of completion for Class IH wells, but rather require three redundant layers of protection: surface casing set and cemented through all USDW's, cemented long-string casing, and tubing with a packer or an equivalent. These levels of protection and the requirement for continuous annulus pressure (i.e., mechanical integrity) monitoring would make these cases of contamination impossible today.

Class I injection wells were suspected as the cause of USDW contamination near Erie, PA (Hammermill Paper wells, 1972). It was suspected (but not proven) that the increase in injection zone pressure attributable to the wells caused waste or formation fluid to move up an unplugged well to a USDW. The unplugged well was five miles from the injectors, and no contamination was found at the injection site. The wells were plugged in 1972.

Current UIC regulations require that the pressure effects of an injection well be addressed. Also, in an area where injection pressures are found to be sufficient to cause migration to a USDW, the operator is required to identify and evaluate all artificial penetrations of the confining zone. Furthermore, the Land Disposal Restrictions Regulation (40 CFR 148) requires a detailed analysis of the fate and transport of the injected waste, and an evaluation of its potential for confinement in the injection zone for 10,000 years. Given the relatively shallow injection zone of the Hammermill wells, it is highly unlikely that the petitions for these wells would have been approved.

EPA studies also indicate that hazardous waste leakage into non-USDWs occurred at eight facilities between 1975 and 1984. Most of these incidents occurred prior to the implementation of State UIC programs and were relatively minor leaks in the area immediately adjacent to the wellbore. The incidents were caused by tubing and casing corrosion and were detected or confirmed by mechanical integrity tests (MITs). The most notable of these cases (Chem Waste Management, six wells, Vickery, Ohio, 1983) involved the unobserved deterioration of the long-string casing in wells without packers (for which continuous annulus pressure monitoring cannot be performed). Current UIC regulations require either a packer or a system that allows comparable protection and capability for continuous monitoring of mechanical integrity. In each case, the construction, monitoring, and MIT requirements of the current regulations would have either prevented the observed failure or detected its occurrence in time to prevent significant leakage.

In addition to these cases, there have been two incidents of well blowouts which resulted in soil contamination at the surface. In both cases, the cause of the blowout was CO_2 gas generated in the injection zone due to incompatibility of the waste with the formation. Both occurred prior to the implementation of a UIC program in the State. Current UIC regulations require that an operator demonstrate the compatibility of the waste with the

materials of well construction and with the injection formation. The regulations also require the operator to demonstrate the capability for emergency shut-in in case of well failure or in response to conditions such as those encountered.

1.6 Class IH Wells Are Safer than Virtually All Other Waste Disposal Practices

The Office of Solid Waste and Emergency Response (OSWER) prepared a study which evaluated the relative risks posed by many waste management practices.[8] The study ranked risks from these different practices based on:

- acute exposure health risks,
- chronic health risks from acute events,
- other health risks (such as cancer risks),
- groundwater sources affected,
- welfare effects, and
- ecological risks.

The study found that Class IH wells are safer than virtually all other waste disposal practices. According to the study, high-risk disposal practices include municipal landfills, hazardous waste storage tanks, and land disposal of hazardous waste. Medium-risk activities include transportation of hazardous materials, municipal waste combustion, and Superfund sites. Hazardous waste injection falls into the low-risk category, along with ocean dumping and ocean incineration.

2.0 EPA PROMULGATED REGULATIONS TO MEET CONGRESSIONAL MANDATES

Part C of the Safe Drinking Water Act (SDWA) of 1974 required EPA to develop a program, called the UIC program, to protect USDWs. The SDWA mandated that EPA:

- publish minimum technical requirements for State UIC programs;

- approve or disapprove State programs based on whether they meet the minimum technical requirements;

- oversee UIC program implementation by States that run their own programs; and

- administer programs in States that do not have approved programs.

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[8]Office of Solid Waste and Emergency Response, *OSWER Comparative Risk Project: Executive Summary and Overview* (OSWER), U.S. EPA, Washington, D.C. #EPA/540/1-89/003, November 1989.

2.1 UIC Class IH Regulations

EPA believes that the initial UIC regulations passed in 1980 were sufficiently stringent to protect USDWs.[9] However, the Agency gained experience and knowledge from implementing and overseeing UIC programs. In a 1985 Report to Congress on Class IH wells,[10] EPA identified ways to make the original regulations even more protective without being unnecessarily burdensome.

In 1986, EPA assembled a Regulatory Negotiation committee consisting of representatives from industry, State and Federal regulatory agencies, and environmental groups. The committee carefully considered both the technical and economic impacts of EPA's proposed regulatory changes to the Class IH program, and the Agency used their findings in developing the final regulation. The more stringent technical requirements were promulgated in July 1988.[11]

The regulations applicable to Class IH wells are described in 40 CFR 124, 144, 145, 146, and 148. They require that all Class I injection wells have a permit to operate and that they meet all applicable administrative and technical criteria set forth in the regulations. Administrative requirements include reporting and financial responsibility requirements. Technical criteria include siting, construction, operating, testing, monitoring, closure, and post-closure requirements.

2.2 Regulations Preventing Contamination from Class IH Wells

The Class IH technical requirements were designed to control the Class IH contamination pathways. Controls for each contamination pathway are listed in 40 CFR 146 and are also summarized below:

Controls to prevent well failure

- Well materials must be compatible with wastes they are likely to contact. Operators are required to conduct corrosion monitoring;

- Wells must be adequately cased and cemented to protect USDWs and isolate the injection zone;

- The long-string casing, injection tubing, and annular seal must be pressure-tested at least annually, and whenever there is a well workover. The bottom-hole cement must be tested annually by a radioactive tracer survey (RTS). Also, a test for fluid movement along the bore hole must be conducted at least once

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[9] 53 FR 28131.

[10] U.S. EPA, *Report to Congress*, p. 1-2.

[11] 53 FR 28118 et seq.

every five years using a noise, temperature, or other EPA-approved logging method. Finally, for certain Class I wells, casing inspection logs must be maintained. These logs are predictive tools to assess developing weaknesses in the well's casing;

- The operator must install and use continuous recording devices to monitor waste injection pressure, flow rate, and temperature. He must also install and use an automatic alarm and shut-down system designed to alert the operator and shut-in the well when pressures, flow rates, or other parameters exceed the allowable limits; and

- If the well is automatically shut down, the operator must identify whether mechanical integrity was lost. A well has mechanical integrity if there is no significant leak in the casing, tubing, or packer and if there is no significant fluid movement through channels adjacent to the well bore outside of the injection interval. If loss of mechanical integrity is found during an automatic shutdown or during routine MIT, the operator must notify EPA, cease injecting fluids, and perform the well workover and remediation plan specified by the Director.

Controls to prevent fluid migration up improperly plugged wells that penetrate the confining zone

- The operator must identify all wells within a two-mile radius of the well bore. In some cases a larger area of review (AOR) may be required if pressure analysis shows that the injection well has a greater pressure radius of influence;

- All wells in the AOR must be examined to determine whether they are adequately completed or plugged, or that there is no potential for fluid movement, hence waste movement up the abandoned well;

- A description of each well and any records of its plugging or completion must be submitted to EPA; and

- A remediation plan must be submitted for wells that EPA determines are improperly plugged, completed or abandoned, or for which plugging or completion information is inadequate. The plan must consist of steps or modifications that will be taken to ensure that fluids will not move up the wells. The plan will be a condition of the permit.

Controls to prevent fluid migration through faults or fractured confining strata

- Wells must be completed such that the injection zone which receives the waste is confined above and below by an impermeable confining zone;

- Injection pressure must be controlled so that new fractures are not created or propagated in the injection zone or the confining formation;

- The confining zone must be laterally continuous and free of faults and transmissive fractures;

- The waste must be chemically compatible with the confining zone, so that dissolution of the confining zone rock does not allow waste to migrate out of the injection zone; and

- The operator must conduct an annual pressure transient test to measure any changes in reservoir characteristics and the pressure increase in the reservoir over time.

Controls to prevent lateral displacement of fluids

- The injection zone must have sufficient permeability, porosity, thickness, and areal extent to prevent fluid movement into USDWs; and

- Information must be provided by the operator on faults, the continuity of injection and confining zones, and the proximity of USDWs to the injection well.

2.3 States Have a Role in Protecting USDWs

After EPA promulgated UIC technical regulations, States were required to adopt regulations that met or exceeded the minimum technical criteria. If State regulations were found to be adequate, the State would be granted permitting and enforcement responsibility, or primacy, for the various classes of wells. If a State did not adopt minimum federal regulations, EPA was required to implement the program for the State. Thirty-five States and territories have received primacy for Class I programs. EPA implements Class I programs in the remaining twenty-two States and territories, including the District of Columbia.

States oversee well operators and EPA conducts oversight reviews of the States to ensure that program requirements are met. Well operators document their adherence to regulations and permit conditions in monthly or quarterly reports. Class IH waste injection well facilities must be inspected by EPA or the State annually. EPA regional staff visit State program offices at least annually and require States to submit non-compliance reports quarterly. The reports describe any operator noncompliance with UIC regulations and permit conditions. They also describe actions States have taken to ensure compliance.

3.0 CONGRESS BANNED HAZARDOUS WASTE INJECTION EXCEPT WHERE PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT IS ENSURED

The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, requires EPA to promulgate regulations identifying hazardous waste and establishing requirements for those who generate, transport, treat, store, or dispose of it.

The 1984 RCRA amendments ban the land disposal of hazardous wastes, including wastes managed by underground injection, unless:

- the waste is treated to reduce concentrations of constituents below hazardous levels or operators use treatment methods specified by the EPA; or

- the operator demonstrates that the waste will not migrate from the injection zone as long as the waste remains hazardous.

4.0 EPA ESTABLISHED A RIGOROUS PROCESS TO DEMONSTRATE PROTECTIVENESS

EPA promulgated standards in July 1988 describing how the no-migration condition could be successfully demonstrated (40 CFR Part 148). EPA requires operators to show that waste will remain totally confined in the injection zone for at least 10,000 years. Alternatively, operators may demonstrate that the waste will decompose or otherwise be attenuated in the injection zone so that it is no longer hazardous. Exhibit V is a flow chart of the petition review process.

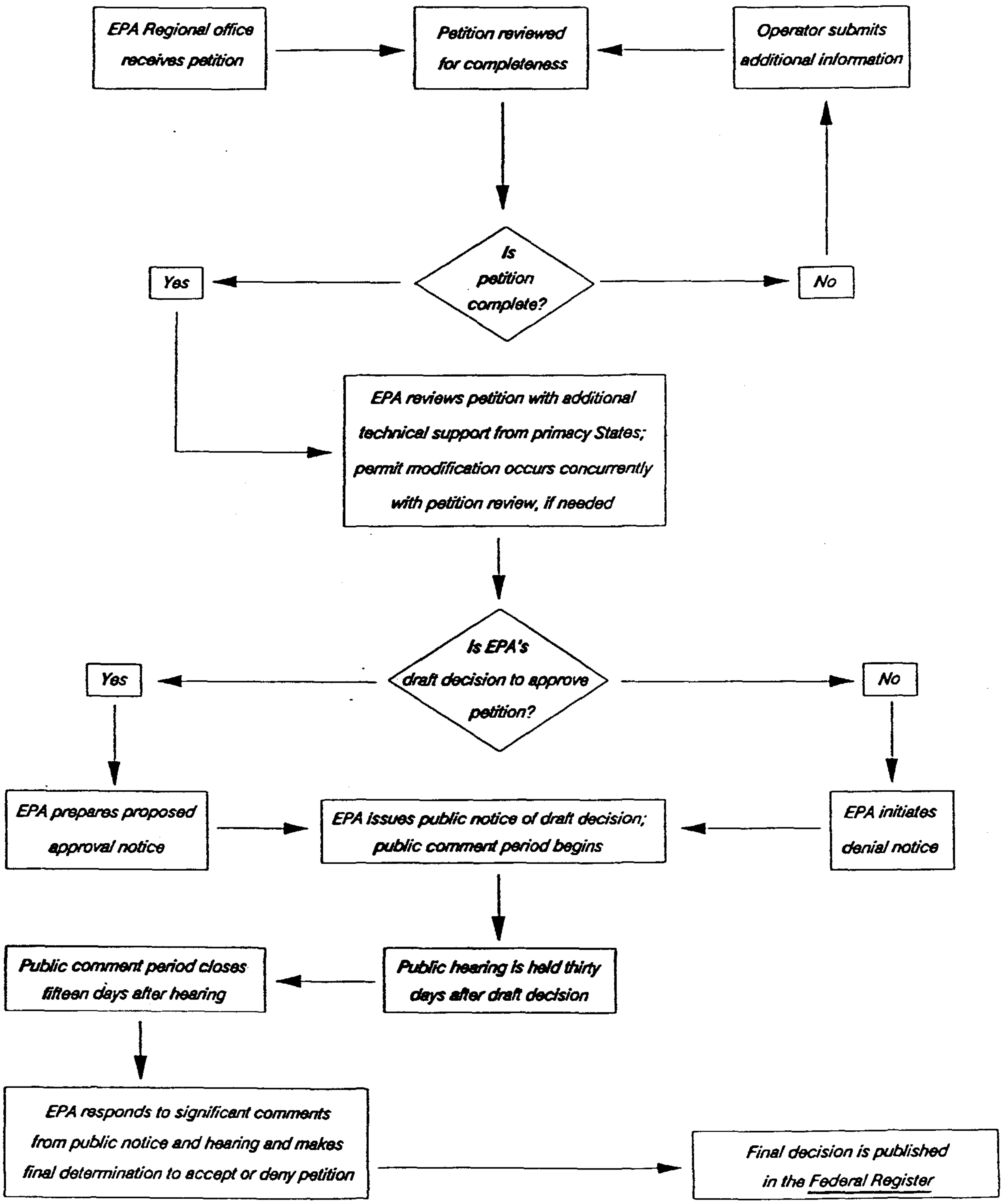
4.1 Operators Submit Extensive Information on the Well and the Site

Currently, operators submit petitions directly to the EPA Regions. The Regions have been given complete authority to approve or disapprove petition submittals. Each petition is a complex technical analysis of every aspect of the well and consists of several volumes which describe:

- Well construction, monitoring, and operation;
- The types, amounts, and processes which generate the waste injected into the well;
- Local and regional geology, and hydrogeology;
- Descriptions of any "potential points of discharge" from the injection zone, such as faults or other penetrations which might enable waste to migrate out of the injection zone; and
- Mathematical models demonstrating that the waste will not migrate from the injection zone into underground sources of drinking water.

Exhibit V

EPA's No-Migration Petition Review Process



Models used in the petitions are mathematical simulations of waste movement and decomposition in the subsurface. The models must be "appropriate for the specific site, waste streams, and injection conditions of the operation."[12] The models must use "conservative values" to predict worst-case scenarios and to "analyze the effect that significant uncertainty may contribute to the demonstration."[13]

4.2 Models are an Effective Method for Predicting Waste Migration

Although environmental groups and some researchers have questioned whether modeling can accurately predict waste migration in the subsurface over the next 10,000 years, EPA, the States, and many scientific experts believe that modeling can be accurately used for the purpose intended in the UIC program. First, EPA notes that modeling does not have to determine the exact location of the waste in 10,000 years, only where the waste will not migrate.[14] Second, the type of fluid-flow modeling used in the no-migration petition demonstrations is considered to be a "well developed and mature science" and that similar modeling has been "used for many years in the petroleum industry."[15] Third, the modeling and its application to predicting Class I waste fate and transport were approved by EPA's Science Advisory Board, a group of independent scientists who advise EPA on scientific issues.[16] Finally, the use of models in regulatory decision-making has precedents in other EPA programs and in the Department of Energy (DOE). EPA uses waste migration and fate models in the Superfund and RCRA programs. DOE has developed similar models for the nuclear waste isolation program.

4.3 EPA Successfully Defended Legal Challenges to the UIC Land Ban Regulations

Both the Chemical Manufacturers Association representing numerous Class I operators and the Natural Resources Defence Council (NRDC) and others challenged specific issues involving EPA's Class I petition process in court. Operators argued that the petition process was unreasonably stringent, whereas NRDC argued that the "no-migration" standard using "hazardous levels" of waste constituents demonstrated in the petition was not stringent enough. In both cases the court upheld EPA's use and interpretation of the "no-migration" standard, and therefore the regulations were upheld as promulgated.

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[12] 40 CFR 148.21(3).

[13] 40 CFR 148.21.

[14] 53 FR 28126.

[15] 53 FR 28127.

[16] 52 FR 32446.

4.4 EPA Regional Offices Coordinate Petition Review

As previously mentioned, Regional EPA offices decide whether a petition should be approved or denied. Petitions from operators in UIC primacy States are also reviewed by the State's UIC program and other appropriate State agencies in addition to EPA Regional staff. Petitions from non-primacy States are reviewed only by Regional personnel, though States are kept informed about the progress of the petitions. EPA Headquarters has the responsibility of assuring that petitions are subjected to equitable review by the various Regions. Both the Regions and Headquarters provide written and verbal guidance to help operators prepare and submit petitions.

4.5 Several People Review Each Petition

EPA uses the "team management" approach to review Class IH petitions, which means that many technical staff members may review a single petition. The strengths of this approach are that each part of a petition is reviewed by a specialist, complicated parts of the petitions are reviewed several times, and issues that require "best professional judgement" are resolved by pooling the experience of several people.

4.6 Local and Regional Geology and Hydrogeology are Reviewed by EPA

A geologist reviews information about the construction, operation, maintenance, and compliance history of the well. The geologist also evaluates descriptions of local and regional geology by reviewing core data, scientific literature, pressure test results, and seismic profiles to look for evidence of faults or fractures which may compromise the integrity of the confining zone. Local seismic activity is evaluated to determine whether fluid injection into the proposed formation has any potential to cause an earthquake that would result in a release of waste. The geologist evaluates the chemical compatibility of the waste with the well construction materials, and with the injection and confining zone rock and fluids. Finally, the petitioner's quality control/quality assurance plan is reviewed to verify that it meets EPA guidelines for all aspects of the demonstration.

Information on artificial penetrations in the area of review is thoroughly studied by EPA to ensure that no migration will occur through unplugged man-made conduits from the injection zone into USDWs. Such conduits include water wells and oil and gas exploration and production wells. The method used to search for all artificial penetrations, both wells currently in use and wells abandoned from past production and exploration, is also assessed. For each abandoned well found, the petitioner must either demonstrate conclusively that the well was properly plugged or that the well will not act as a conduit for wastes to enter USDWs.

4.7 The Petition Model is Evaluated

The modeling expert is responsible for ensuring that the petitioner validated and calibrated the model and performed sensitivity analysis on the assumptions. This person also ensures that the petitioner selected a model that takes into account all significant processes that affect waste mobility and transformation, and that is sensitive to subsurface processes.

The modeler has to evaluate the accuracy of the model's predictions compared to actual conditions at the site. Assumptions that were used in the model are evaluated to make sure the petitioner chose conservative assumptions which predict "worst-case" scenarios. The model is analyzed to identify the most important input parameters, and the parameters are evaluated over a wide range of possible values. This sensitivity analysis presents a spectrum of least-to-worse case scenarios and evaluates the reasonableness of the operator's technical data.

4.8 Operators Must Correct Petition Deficiencies

As the petition is reviewed, a list of any deficiencies, noted by Regional and State reviewers is compiled. A "notice of deficiency" (NOD) is then sent to the petitioner. Each deficiency must be corrected before the petition review can be completed. Petitioners may receive two, three, or more notices of deficiency before a decision is made on their petition.

The well's UIC permit is reviewed and modified as needed. The permit conditions must be consistent with conditions described in the petition. For example, if the permit allows more waste to be injected into the formation than that modeled in the petition, then the permit is modified to limit injection to the amount modeled.

If the petition deficiencies cannot be addressed by the operator, or if the petition review shows that migration of waste to USDWs might occur, EPA notifies the petitioner that it plans to deny the petition. Generally, EPA allows the petitioner to withdraw the petition. Twenty out of 51 petitions have been voluntarily withdrawn. If an operator refuses to withdraw an inadequate petition, EPA will formally deny the petition in the Federal Register. No petition has been formally denied as of August 1, 1991.

4.9 The Public Participates in the Decision Process

EPA publishes a draft notice of its decision to approve or deny a petition usually 30 days before the Agency offers a public hearing on the petition. The public is given 45 days from publication of the draft notice to comment on the proposed petition decision. EPA must respond to all significant comments. Generally, the public hearing is held in the well operator's community. When the final decision is made for a petition, a notice is published in the Federal Register, and the petitioner is sent a letter outlining the conditions of the decision. These may include the type and amount of waste that can be injected, limitations of injection pressure, or other technical considerations. If new information that contradicts the information in the petition comes to light after an approval is granted, or if the petitioner does not abide by the conditions of the permit or petition approval, EPA can exercise its authority to revoke petition approval.[17] In addition, there are procedures to modify or reissue no migration petitions if information by the operator is changed.

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[17] 40 CFR 148.24

5.0 RESULTS OF THE PETITION PROCESS

Of the 95 Class IH facilities operating in the late 1970s before Class IH regulations were promulgated and before the land disposal restrictions petition process was established, 68 petitions were filed, and 28 operators did not file. (See Exhibit VI.) Note that one facility submitted both a waste transformation and a no migration petition; therefore, the number of petitions filed is one greater than the number of facilities.

5.1 EPA Spends an Average of One Person-Year Reviewing Each Petition

EPA Regional and State UIC staff perform an exhaustive review of each petition. The States and Regions devote substantial attention to the review of each petition, expending an average of approximately one-person year on each. In most cases, Regions commit several professionals full-time to this review. The level of effort devoted to review of the Class I petitions demonstrates EPA's serious commitment to protection of USDWs.

Since the Class I wells are concentrated in just a few areas of the U.S., some Regions accepted more of the petition review burden than others. Region VI, for example, has more wells than Regions IV, V, and VII combined. For almost a year Region VI had sixteen full-time staff members reviewing the petitions. EPA Regions IV and V dedicated a large number of UIC staff for petition review as well.

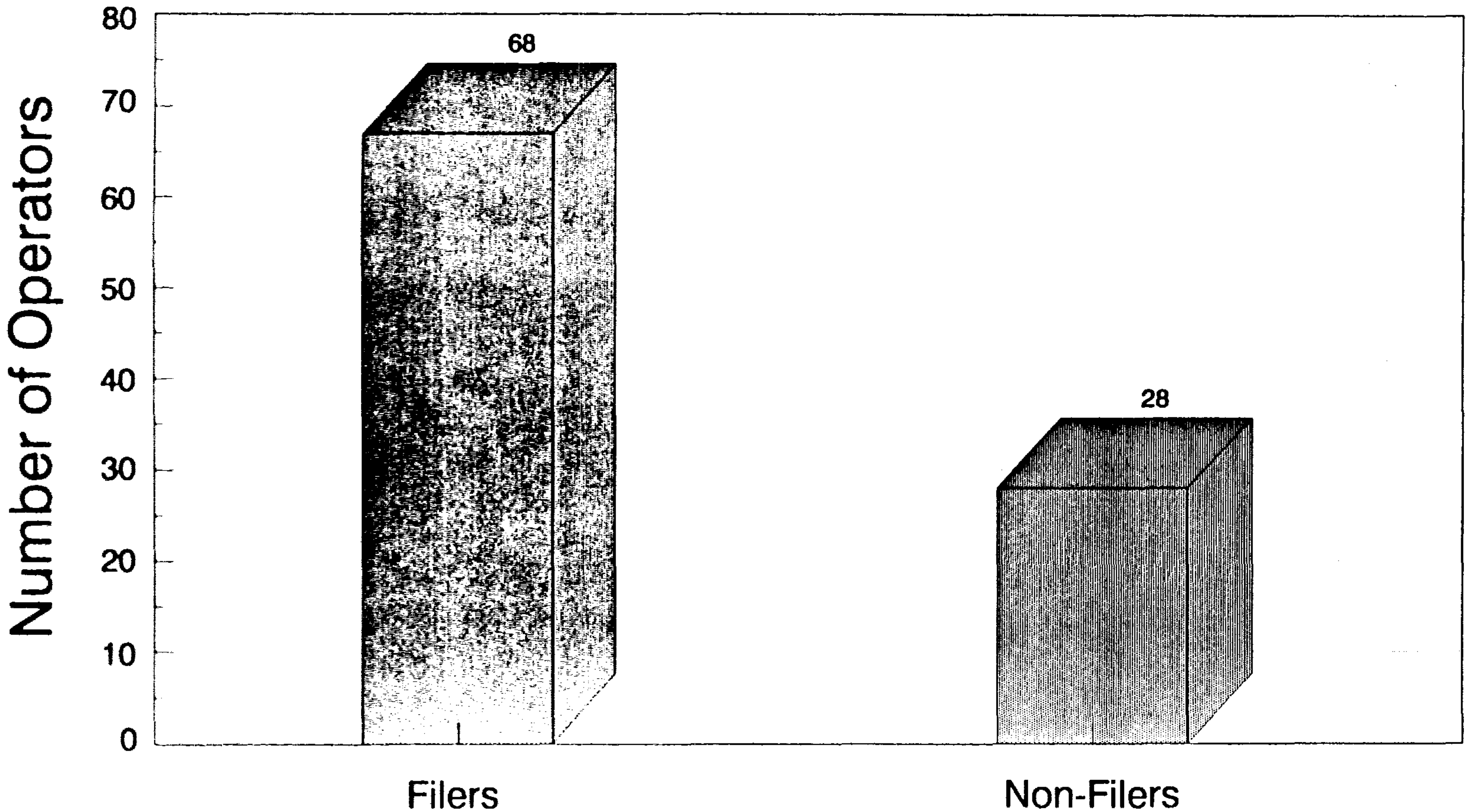
5.2 Well Operators Spend an Average of $343,000 per Petition

Well operators were surveyed to determine the cost of preparing complete petitions. Most operators hired technical consultants to prepare the petition. Operators reported contractor cost only; they typically did not include internal company time spent on the petition review. Thus, the costs cited here are lower limits. Of the 35 operators who prepared complete petitions, 33 provided cost information. They reported that the average amount spent to prepare each petition was $343,000. The range was $50,000 to $1,200,000 with a mode of $290,000.

The cost of the petitions exceeded EPA's expectations. In a Regulatory Impact Analysis prepared before the petition process was finalized, EPA assumed that petitions would only describe fluid migration and transformation. However, permit issues from 40 CFR 146 were raised (such as siting, construction, monitoring, reporting, and testing) which increased petition costs. Also, EPA did not realize that operators would spend substantial amounts of money responding to repeated notices of deficiency before a final decision could be made on a petition.

Petitions typically consist of several full three-ring binders containing thousands of pages of detailed technical information. A petition for a single facility may take up to two to three feet of shelf space. These extensive petitions reflect detailed, rigorous analysis of migration potential. It is very apparent that the operators took the petition process very seriously, as demonstrated by the cost they applied to each petition.

Exhibit VI
Number of Facilities that Filed and Did Not File No-Migration Petitions



5.3 Changes in Waste Management Practices

Of the 36 former Class IH facilities that withdrew or did not submit petitions (see Exhibit VII):[18]

- 20 now inject only non-hazardous fluids;
- 11 are plugged and abandoned; and
- 5 are temporarily abandoned.

While all of these changes were not a result of the Class I petition process, it is reasonable to conclude that some of these changes in waste handling were a direct outcome of the regulations.

The petition process may have selectively eliminated Class I disposal activities, allowing only highly sound Class I disposal operations to continue. Several Class I disposal facilities withdrew or did not submit petitions because they may not have met meet minimum federal standards for 40 CFR 146 and 148.

Facilities that withdrew or did not submit petitions have changed their hazardous waste management practices in the following ways (see Exhibit VIII):

- 13 are no longer generating the hazardous waste;
- 2 now ship the hazardous waste off-site;
- 14 treat their waste on-site so that it is no longer hazardous; and
- 7 have closed their Class I facilities entirely.

Although it is not clear to what degree, the Class I petition process can be presumed to have reduced the amount of hazardous waste produced. Some injectors chose to eliminate their hazardous waste stream entirely, while others chose alternative disposal methods. The more stringent regulations have resulted in safer operating wells, more monitoring, and stricter controls.

[18] This does not include two operators that are currently injecting hazardous waste without petition approval because they have received an extension from EPA.

Exhibit VII
Class IH Well Status for Former Class IH Facilities that Withdrew or Did Not Submit Petitions

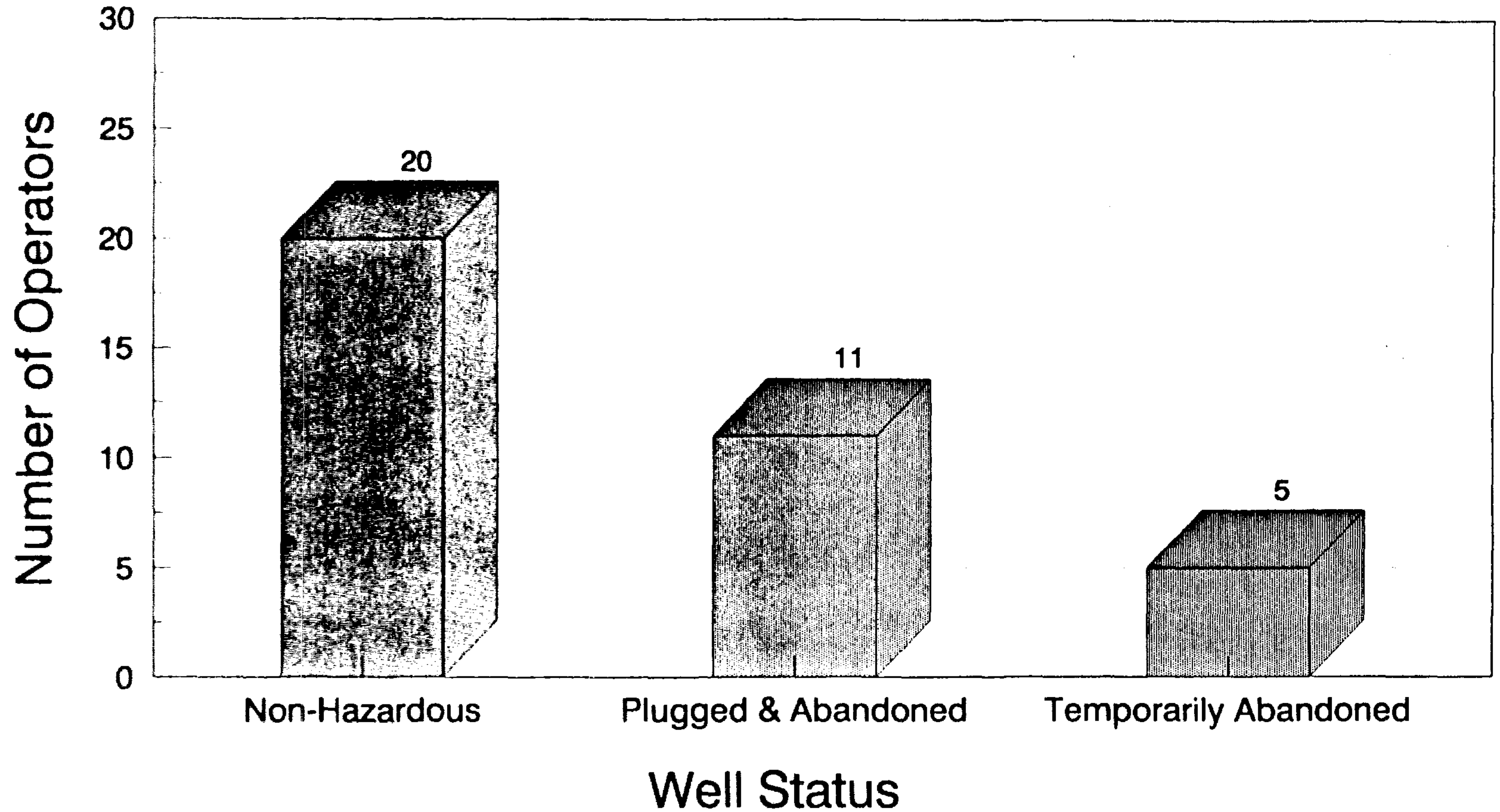
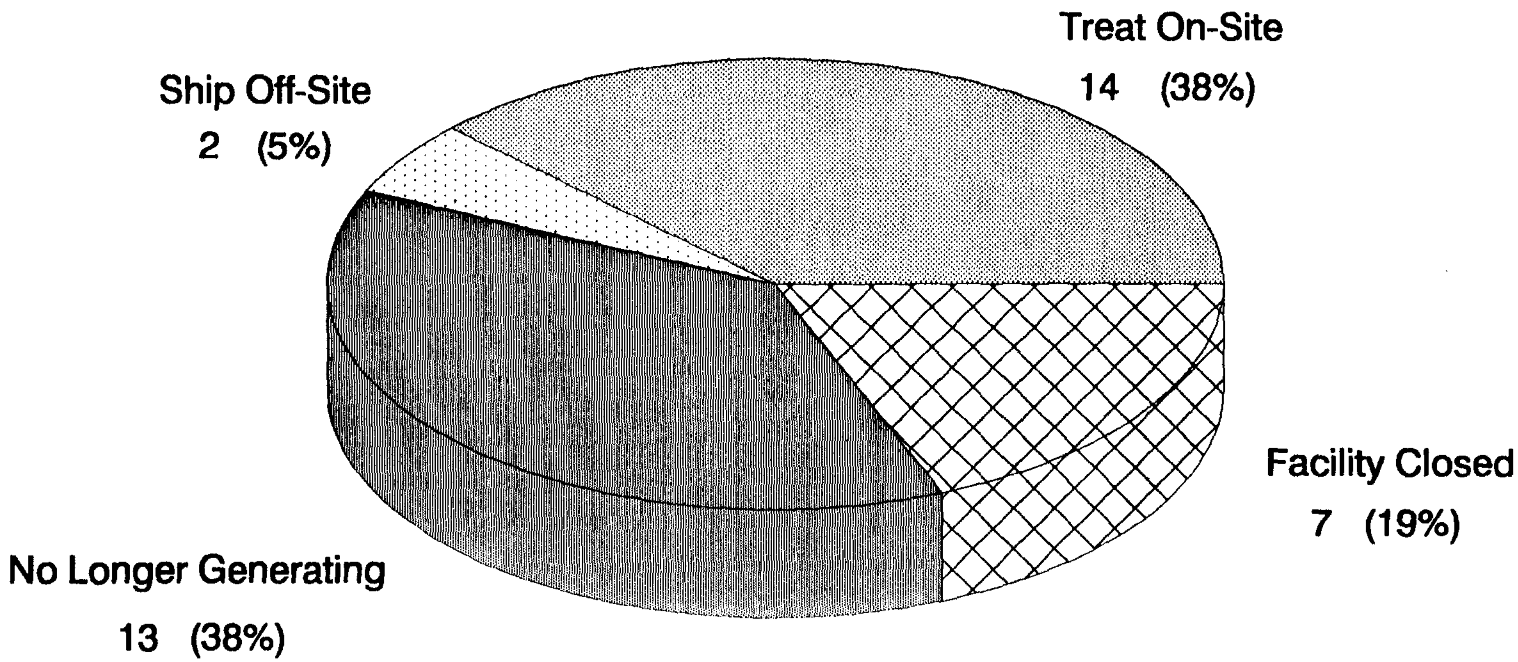


Exhibit VIII
Hazardous Waste Disposal Practices of Facilities that Withdrew or Did Not Submit Petitions



5.4 Most Operators Who Submitted a Petition Successfully Demonstrated No Migration

Most facilities that submitted petitions were able to demonstrate no migration (see Exhibit IX):

- 36 facilities have had their petitions approved;
- 20 of the facilities that initially submitted a petition later withdrew; and
- 14 petitions are still pending.[19]

6.0 CONCLUSIONS

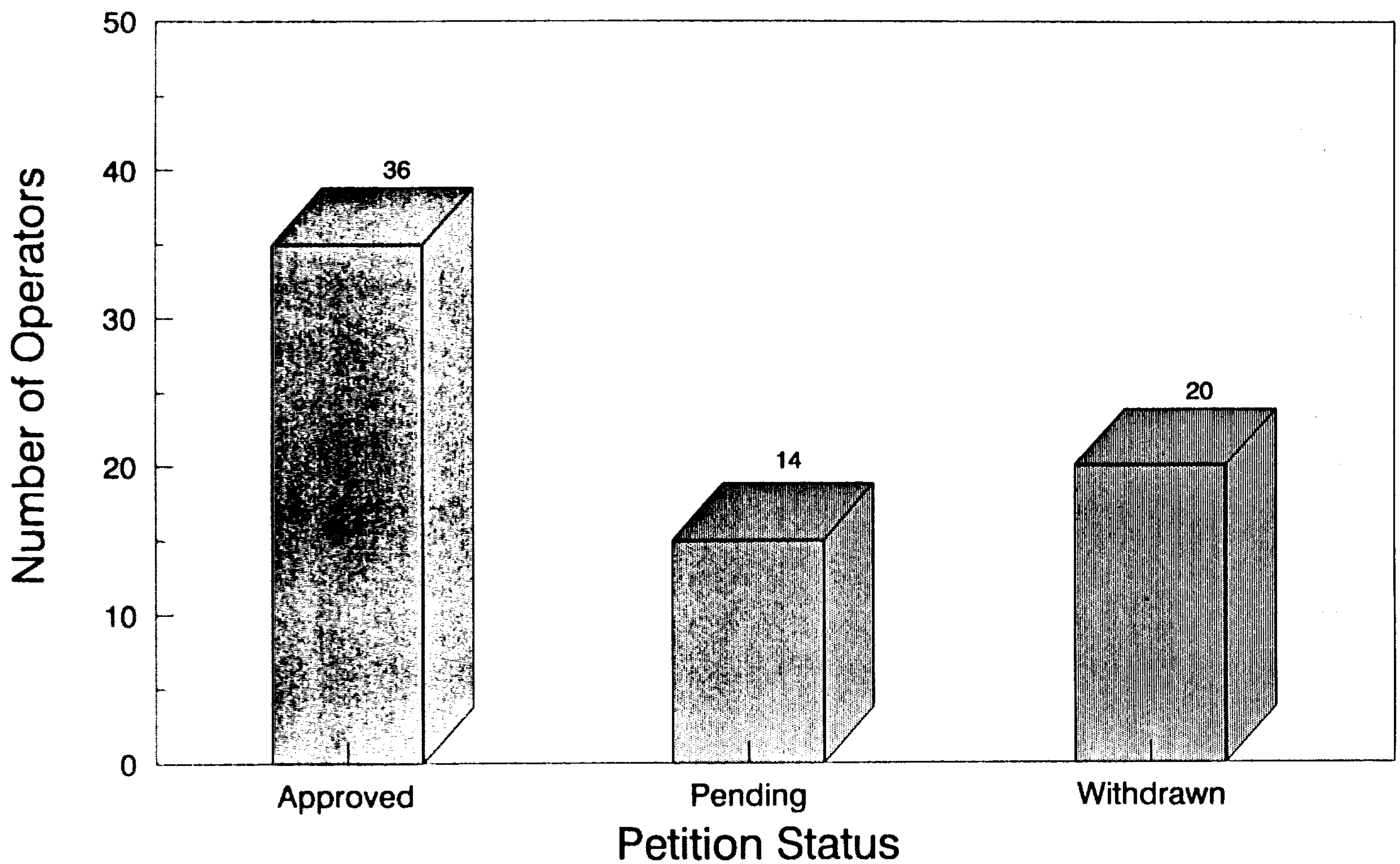
EPA has taken a strong protective stand to assure that USDWs are not endangered in the short-term (i.e. life of the well and UIC permit) or the long term (i.e. 10,000 years). First, EPA has strengthened the Class I operating regulations found in 40 CFR Part 146. EPA required operators to submit petitions that would demonstrate that waste will not migrate from the injection zone for as long as the waste remains hazardous.

Operators who submitted petitions performed expensive and thorough technical analysis of every facet of their injection operation. It is clear from the level of effort and expertise applied to the petition review process that EPA performed a very careful and rigorous review of the petitions.

Overall, the number of Class IH injection facilities has decreased from 95 to 51 from the period right before Class IH regulations were promulgated until now. In addition, the volume of hazardous wastes injected has been reduced from 11.5 billion gallons in 1983 to 9 billion gallons in 1990. This reduction in hazardous wastes injected is due at least in part to the Class I Hazardous Waste Restrictions. The Class IH wells that continue to operate today are subject to strict technical requirements, and have been evaluated by a rigorous, comprehensive process that ensures that they do not endanger underground sources of drinking water.

[19]This includes an operator of a non-hazardous well that may inject hazardous waste in the future.

Exhibit IX
Status of No-Migration Petitions



REFERENCES

Engineering Enterprises, Inc., *Class I Hazardous Waste Injection Wells Evaluation of Non-Compliance Incidents*, prepared for the U.S. EPA, Office of Drinking Water, UIC Contract No. 68-01-7011, 1986.

CH2MHill, *Class I Injection Well Survey-Phase I Report: Survey of Selected Sites*, prepared for the Underground Injection Practices Council, Oklahoma City, Oklahoma, 1986.

W. Gordon and J. Bloom, *Deeper Problems: Limits to Underground Injection as a Hazardous Waste Disposal Method*, Natural Resources Defense Council, Inc., New York, N.Y.

Hazardous Waste: Controls Over Injection Well Disposal Operations, U.S. General Accounting Office, August 1987.

Office of Solid Waste and Emergency Response, *OSWER Comparative Risk Project: Executive Summary and Overview* (OSWER), U.S. EPA, Washington, D.C. #EPA/540/1-89/003, November 1989.

"Underground Injection Control Program; Hazardous Waste Disposal Injection Restrictions and Requirements for Class I Wells; Final Rule," (40 CFR Parts 124, 144, 146, and 148), Federal Register, July 26, 1988.

U.S. EPA, *Report to Congress on the Injection of Hazardous Waste*, EPA 570/9-85-003, May 1985.

U.S. General Accounting Office, *Hazardous Waste: Controls Over Injection Well Disposal Operations*, Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives, August 1987.

40 CFR Parts 100 To 149, Code of Federal Regulations, July 1, 1990.